Chapter 9. San Diego Regional Survey Macrobenthic Communities

INTRODUCTION

The City of San Diego has conducted regional benthic monitoring surveys off the coast of San Diego since 1994 (see Chapter 1). The main objectives of these surveys are: (1) to characterize benthic conditions of the large and diverse coastal region off San Diego; (2) to characterize the ecological health of the marine benthos in the area; (3) to gain a better understanding of regional conditions in order to distinguish between areas impacted by anthropogenic versus natural events.

These annual surveys were based on an array of stations randomly selected each year by the United States Environmental Protection Agency (USEPA) using the USEPA probability-based EMAP design. The 1994, 1998, and 2003 surveys off San Diego were conducted as part of the Southern California Bight 1994 Pilot Project (SCBPP) and the Southern California Bight 1998 and 2003 Regional Monitoring Programs (Bight '98, Bight '03; see Bight '98 Steering Committee 1998, Ranasinghe et al. 2003). These large-scale surveys included other major southern California dischargers, and included sampling sites representing the entire Southern California Bight (i.e., Cabo Colnett, Mexico to Point Conception, USA). The same randomized sampling design was used in surveys limited to the San Diego region in 1995–1997, 1999–2002, and 2005. In 2006, the City revisited the 1996 randomized survey sites to allow for comparisons of conditions after 10 years.

This chapter presents an analysis and interpretation of the benthic macrofaunal data collected during the San Diego 2006 regional survey. Included are descriptions and comparisons of the region's soft-bottom macrobenthic assemblages, and analyses of benthic community structure.

MATERIALS AND METHODS

Collection and Processing of Benthic Samples

The July 2006 survey covered an area off San Diego, CA from Del Mar south to the United States/Mexico border (**Figure 9.1**). Site selection was based on the USEPA probability-based EMAP sampling design used in 1996 (City of San Diego 1997). The area sampled included the section of the mainland shelf from nearshore to shallow slope depths (12–202 m). Although 40 sites were initially selected for the 1996 and 2006 surveys, sampling at 7 sites in 1996

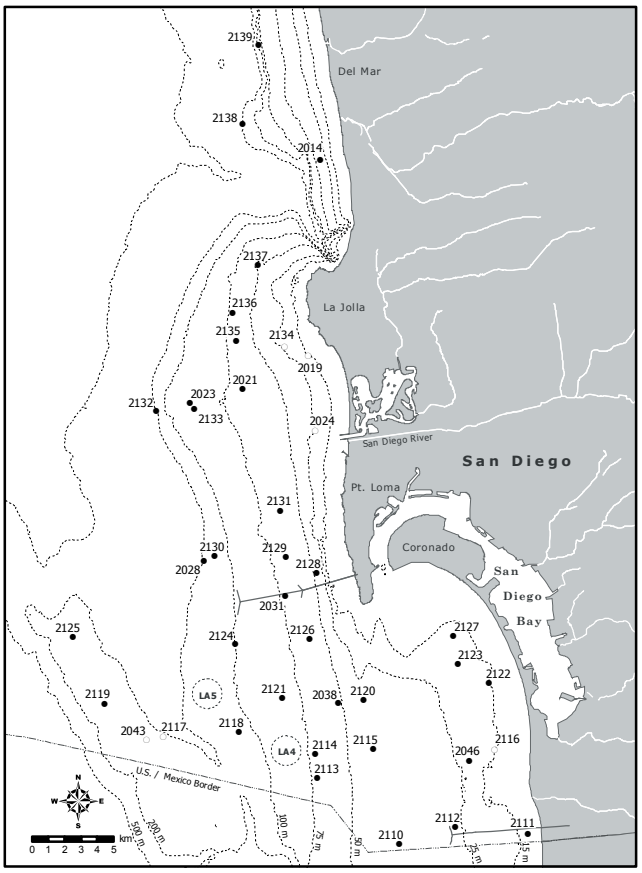

Figure 9.1
Randomly selected regional macrobenthic stations sampled off San Diego, CA (August, 2006). Open circles represent abandoned stations (see text).

and 6 sites in 2006 was unsuccessful due to the presence of rocky reefs. In addition, 7 sites (2014, 2021, 2023, 2028, 2031, 2038, 2046) were sampled in 1995, 1996, 1997, 2005, and 2006.

Samples for benthic community analyses were collected from one 0.1 m^2 van Veen grab at each station. The criteria established by the USEPA to ensure consistency of grab samples were followed with regard to sample disturbance and depth of penetration (USEPA 1987). All samples were sieved aboard ship through a 1.0 mm mesh screen. Organisms retained on the screen were relaxed for 30 minutes in a magnesium sulfate and seawater solution and then fixed with 10% buffered formalin. After a minimum of 72 hours, each sample was rinsed with fresh water and transferred to 70% ethanol. All organisms were sorted from the debris into groups by a subcontractor and identified to species or the lowest taxon possible and enumerated by City of San Diego marine biologists.

Data Analyses

The following community structure parameters were calculated for each station: species richness (number of species per 0.1 m^2 grab), abundance (number of individuals per grab), Shannon diversity index (H' per grab), Pielou's evenness index (J' per grab), Swartz dominance (minimum number of species accounting for 75% of the total abundance in each grab), Infaunal Trophic Index (ITI per grab, see Word 1980), and Benthic Response Index (mean BRI per grab, see Smith et al. 2001). These data are summarized according to depth strata used in the Bight'98 and Bight'03 surveys: shallow water (5–30 m), mid-depth (31–120 m), and deep (121–200 m).

Multivariate analyses were performed using PRIMER v6 (Plymouth Routines in Multivariate Ecological Research) software to examine spatiotemporal patterns in the overall similarity of benthic assemblages in the region (see Clarke 1993, Warwick 1993). These analyses included classification (cluster analysis) by hierarchical agglomerative clustering with group-average linking and ordination by non-metric multidimensional scaling (MDS). The macrofaunal abundance data were square root transformed and the Bray-Curtis measure of similarity was used as the basis for both classification and ordination. SIMPER (similarity percentage) analysis was used to identify individual species that typified each cluster group. Patterns in the distribution of macrofaunal assemblages were compared to environmental variables by overlaying the physicochemical data onto MDS plots based on the biotic data (see Field et al. 1982).

RESULTS AND DISCUSSION

Community Parameters

Number of species

A total of 654 macrobenthic taxa were identified during 2006. Of these, 34% represented rare or unidentifiable taxa that were recorded only once. The number of taxa per station ranged from 40 to 133 (**Table 9.1a**). This variation in species richness generally is consistent with recent years but lower than values in 1996 when the average number of taxa per 0.1 m^2 ranged from 47 to 266 (see **Table 9.1b**). Polychaete worms made up the greatest proportion of species, accounting for 49% of the taxa per site during 2006. Crustaceans represented 23% of the taxa, molluscs 16%, echinoderms 5%, and all other taxa combined about 8%. These percentages are generally similar to those observed during previous years (e.g., City of San Diego 2006).

Macrofaunal abundance

Macrofaunal abundance averaged 136–639 individuals per 0.1 m^2 in 2006 versus 45–1219 individuals per 0.1 m^2 in 1996 (Table 9.1a, b). The greatest number of animals in 2006 occurred at stations 2137 and 2128, both of which averaged over 600 individuals per 0.1 m^2. Five other stations had abundance values greater than 400 individuals per 0.1 m^2, while most sites had values between 200–400 individuals per 0.1 m^2. Region wide, only 5% fewer individuals were collected in 2006 than in 1996.

Polychaetes were the most abundant animals in the region, accounting for about 48% of the different assemblages during 2006. Crustaceans averaged

Table 9.1a

Benthic community parameters at regional stations sampled during 2006: Species richness (SR), no. species/0.1 m^2 ; abundance (Abun), no. individuals/0.1 m^2 ; Shannon diversity index (H'); evenness (J'); Swartz dominance (Dom), no. species comprising 75% of a community by abundance; benthic response index (BRI); infaunal trophic index (ITI).

Station	Depth (m)	SR	Abun	H'	J'	Dom	BRI	ITI
Inner shelf								
2111	12	40	219	2.9	0.78	10	22	72
2122	16	58	140	3.6	0.90	23	27	81
2127	16	50	175	3.3	0.85	19	26	76
2123	19	85	365	3.4	0.76	23	31	74
2046	22	72	242	3.6	0.85	24	22	87
2112	26	95	385	3.8	0.82	31	25	82
Mean		67	254	3.4	0.83	22	26	79
Mid shelf								
2128	37	119	609	3.9	0.82	30	24	76
2014	38	124	405	4.2	0.87	42	20	77
2120	39	130	452	4.4	0.90	47	21	80
2110	40	77	240	3.8	0.87	28	11	83
2115	42	66	236	3.4	0.82	22	20	77
2137	48	125	639	4.1	0.85	39	8	83
2038	52	128	419	4.3	0.88	47	17	85
2126	62	76	323	3.2	0.74	19	9	93
2131	63	101	334	3.7	0.80	30	8	87
2135	66	76	323	3.4	0.78	24	6	89
2129	67	79	306	3.6	0.82	24	11	88
2021	67	103	299	3.8	0.83	37	8	88
2114	68	112	356	4.1	0.87	40	15	74
2113	69	73	246	3.8	0.88	27	17	75
2136	69	115	440	4.0	0.84	37	3	82
2031	74	72	377	3.0	0.71	16	13	89
2139	77	108	345	4.1	0.88	43	5	83
2121	83	133	401	4.1	0.83	47	7	87
2133	89	106	263	4.0	0.86	41	6	84
2023	90	73	252	3.5	0.81	23	7	85
2124	100	92	258	4.0	0.88	37	6	77
Mean		99	358	3.8	0.84	33	12	83
Outer shelf								
2118	123	85	213	4.1	0.92	40	6	79
2119	145	81	212	3.9	0.89	34	-2	75
2130	147	86	298	3.7	0.83	27	13	78
2125	157	110	311	4.1	0.88	40	0	78
2138	190	74	273	3.6	0.84	25	22	80
2028	190	62	147	3.6	0.88	27	13	82
2132	197	63	136	3.9	0.93	30	13	83
Mean		80	227	3.8	0.88	32	9	79
All stations								
Mean		90	313	3.8	0.84	31	14	81
Min		40	136	2.9	0.71	10	-2	72
Max		133	639	4.4	0.93	47	31	93

Table 9.1b

Benthic community parameters at regional stations sampled during 1996: Species richness (SR), no. species/0.1 m^2 ; abundance (Abun), no. individuals/0.1 m^2 ; Shannon diversity index (H'); evenness (J'); Swartz dominance (Dom), no. species comprising 75% of a community by abundance; benthic response index (BRI); infaunal trophic index (ITI).

Station	Depth (m)	SR	Abun	H'	J'	Dom	BRI	ITI
Inner shelf								
2111	12	33	83	2.1	0.60	6	22	66
2122	16	58	45	3.2	0.80	18	21	70
2127	16	47	63	3.1	0.81	18	19	75
2123	19	85	155	3.7	0.83	28	23	77
2046	22	56	53	2.9	0.72	20	25	79
2112	26	63	76	3.4	0.82	23	25	77
Mean		57	79	3.1	0.76	19	23	74
Mid shelf								
2128	37	147	347	4.0	0.80	42	21	77
2014	38	155	386	4.3	0.85	43	19	83
2120	39	146	285	4.2	0.83	44	19	83
2110	40	73	268	3.4	0.79	12	11	86
2115	42	155	146	4.2	0.83	25	26	75
2137	48	266	1219	4.6	0.83	42	10	86
2038	52	167	454	4.1	0.80	42	10	86
2126	62	113	417	3.8	0.80	18	21	91
2131	63	110	522	3.8	0.81	8	11	93
2135	66	134	713	4.0	0.81	9	8	84
2129	67	122	395	3.9	0.81	17	13	92
2021	67	165	838	4.3	0.84	34	8	79
2114	68	163	346	4.1	0.80	45	11	81
2113	69	125	212	4.2	0.86	38	10	84
2136	69	130	519	3.9	0.80	15	4	88
2031	74	91	432	3.6	0.80	7	10	95
2139	77	162	370	4.2	0.82	47	7	84
2121	83	120	427	3.7	0.77	17	9	89
2133	89	122	263	3.8	0.79	21	3	89
2023	90	119	226	3.9	0.83	31	6	82
2124	100	128	342	3.9	0.80	29	3	84
Mean		139	435	4.0	0.81	28	12	85
Outer shelf								
2118	123	128	288	4.1	0.85	34	6	84
2119	145	125	300	3.8	0.79	32	-5	82
2130	147	114	265	3.8	0.80	30	10	87
2043	157	59	80	3.2	0.77	16	2	75
2138	190	97	180	3.6	0.79	27	8	88
2028	190	62	120	3.2	0.77	22	11	87
Mean		98	206	3.6	0.80	27	5	84
All stations								
Mean		116	328	3.8	0.80	26	12	83
Min		47	45	2.9	0.72	7	-5	70
Max		266	1219	4.6	0.86	47	26	95

20% of the animals at a station, molluscs about 13%, echinoderms 14%, and all remaining taxa combined 5%. These values were similar to those observed in previous years (see City of San Diego 2006).

Species diversity and dominance

Species diversity (H') varied among stations, and ranged from 2.9 to 4.4 (Table 9.1a). Although most of the stations had values between 3.0 and 4.0, stations with the highest diversity (i.e., ≥4.0, n=12) were found predominantly along the mid shelf. The lowest value occurred at station 2111, a shallow water station located near the US/Mexico border. Diversity values were similar to averages at 1996 stations which ranged from 2.9 to 4.4 (Table 9.1b).

Species dominance was measured as the minimum number of species whose combined abundance accounts for 75% of the individuals in a sample (Swartz et al. 1986, Ferraro et al. 1994). Consequently, dominance as discussed herein is inversely proportional to numerical dominance, such that low index values indicate communities dominated by few species. These values varied widely throughout the region, averaging from 10 to 47 species per station in 2006. The pattern of dominance across depth strata was similar to that of diversity. The 3 stations with dominance values <20 also had the lowest H' values. Dominance at stations in 1996 averaged from 7 to 47 species per station, similar to 2006 (Table 9.1b).

Environmental disturbance indices: ITI and BRI

Average Infaunal Trophic Index (ITI) values were slightly higher than in 2005, but generally similar to those of recent years and ranged from 72 to 93 throughout the San Diego region (Table 9.1a). The lowest value occurred at station 2111 (ITI=72). ITI values >60 are generally considered characteristic of normal benthic conditions (Bascom et al. 1979, Word 1980). ITI values in 1996 were very similar to those in 2006, averaging from 70 to 95.

Similarly, Benthic Response Index (BRI) values at most stations were indicative of undisturbed communities or "reference conditions." Index values below 25 suggest undisturbed communities or "reference conditions," and those in the range of 25–33 represent "a minor deviation from reference condition," (Smith et al. 2001). Values greater than 44 indicate a loss of community function. BRI values throughout the San Diego Region were generally indicative of reference conditions in 2006 (see Table 9.1a). For example, all of the mid and outer shelf stations (depth>30 m) had BRI values <25. Index values ≥25 were restricted to 4 stations located in shallower depths where the BRI is less reliable. Three stations had BRI values ≥25 in 1996: 2046, 2112, 2115 (Table 9.1b).

Dominant Species

Most assemblages in the San Diego region were dominated by polychaete worms and brittle stars. For example, the list of dominant fauna in **Table 9.2** includes 12 polychaetes, 4 echinoderms, 3 molluscs, and 2 crustaceans. The ophiuroid *Amphiodia urtica* was the most numerous species, averaging 25 individuals per sample. However, since juvenile ophiuroids usually cannot be identified to species and are recorded at the generic or familial level (i.e., *Amphiodia* sp or Amphiuridae, respectively), this number underestimates actual populations of *A. urtica*. The only other species of *Amphiodia* that occurred in this assemblage in 2006 were *A. digitata* and *A. psara*, which accounted for 20 individuals. If the values for *A. urtica* abundance are adjusted to include juveniles, then the estimated density becomes about 35 animals per 0.1 m^2. The second most abundant species was the cirratulid polychaete *Monticellina siblina*. The spionid polychaete, *Prionospio jubata,* was third in total abundance. Polychaetes comprised 8 of the 10 most frequently collected species per occurrence. Several polychaete species were found in high numbers at only a few stations (e.g., *Notoproctus pacificus*).

Classification of Assemblages and Dominant Macrofauna

Classification analysis discriminated between 7 habitat-related benthic assemblages (cluster groups A–G) during 2006 (**Figures 9.2, 9.3**). These assemblages differed in terms of their species

Table 9.2

Dominant macroinvertebrates at regional benthic stations sampled during 2006. Included are the most abundant species overall, the most abundant per occurrence, and the most frequently collected (or widely distributed) species. Abundance values are expressed as mean number of individuals per 0.1 m^2 grab sample.

Species	Higher taxa	Percent occurence	Abundance per sample	Abundance per occurence
Paraprionospio pinnata	Polychaeta: Spionidae	97	3.6	3.7
Prionospio jubata	Polychaeta: Spionidae	88	7.3	8.3
Spiophanes duplex	Polychaeta: Spionidae	82	6.9	8.4
Euclymeninae sp *A*	Polychaeta: Maldanidae	82	3.9	4.8
Amphiuridae	Echinodermata: Ophiuroidea	74	7.1	9.6
Mediomastus sp	Polychaeta: Capitellidae	74	4.0	5.4
Maldanidae	Polychaeta: Maldanidae	71	3.0	4.2
Glycera nana	Polychaeta: Glyceridae	71	2.6	3.8
Spiophanes berkeleyorum	Polychaeta: Spionidae	68	2.4	3.5
Ampelisca pugetica	Crustacea: Amphipoda	65	2.3	3.5
Leptochelia dubia	Crustacea: Tanaidacea	62	4.5	7.3
Amphiodia sp	Echinodermata: Ophiuroidea	59	9.6	16.4
Amphiodia urtica	Echinodermata: Ophiuroidea	56	24.8	44.4
Monticellina siblina	Polychaeta: Cirratulidae	53	11.1	20.9
Axinopsida serricata	Mollusca: Bivalvia	50	5.6	11.2
Spiophanes kimballi	Polychaeta: Spionidae	35	4.7	13.4
Spiophanes bombyx	Polychaeta: Spionidae	35	4.7	13.3
Caecum crebricinctum	Mollusca: Gastropoda	9	1.1	12.0
Notoproctus pacificus	Polychaeta: Maldanidae	3	2.4	83.0
Mactridae	Mollusca: Bivalvia	3	0.8	28.0
Dougaloplus sp SD1	Echinodermata: Ophiuroidea	3	0.4	14.0

composition, including the specific taxa present and their relative abundances. The dominant species composing each group are listed in **Table 9.3**. An MDS ordination of the station/survey entities confirmed the validity of cluster groups A–G. Similar to previous random sample surveys of the region, depth, sediment grain size, and organic composition were the primary factors affecting the distribution of assemblages (Bergen et al. 1998; see **Figure 9.4**).

Cluster group A consisted of one station (2110, 40 m) with coarse sediments (0% fine particles) and contained 77 taxa and 240 individuals per 0.1 m^2. Total organic carbon (TOC) concentration at this station was less than 0.1%. Unidentified onuphid polychaetes (Onuphidae, *Moorenuphis* sp) were the most abundant animals characterizing this group, followed by the spionid *Spiophanes bombyx* and the crustacean *Foxiphalus obtusidens*.

Cluster group B comprised the shallowest station 2111 (12 m). The sediments at this site were generally mixed (23% fines) and TOC concentration was 0.3%. Group B contained the fewest taxa (40) and the second lowest abundance (219 individuals per 0.1 m^2) among all the groups. Dominate species included the polychaete *Scoletoma* sp, unidentified molluscs of the family Mactridae, and the bivalve *Tellina modesta*. Other characteristic taxa in this assemblage included the sabellid polychaete *Chone* sp SD1 and the gastropod *Nassarius* sp.

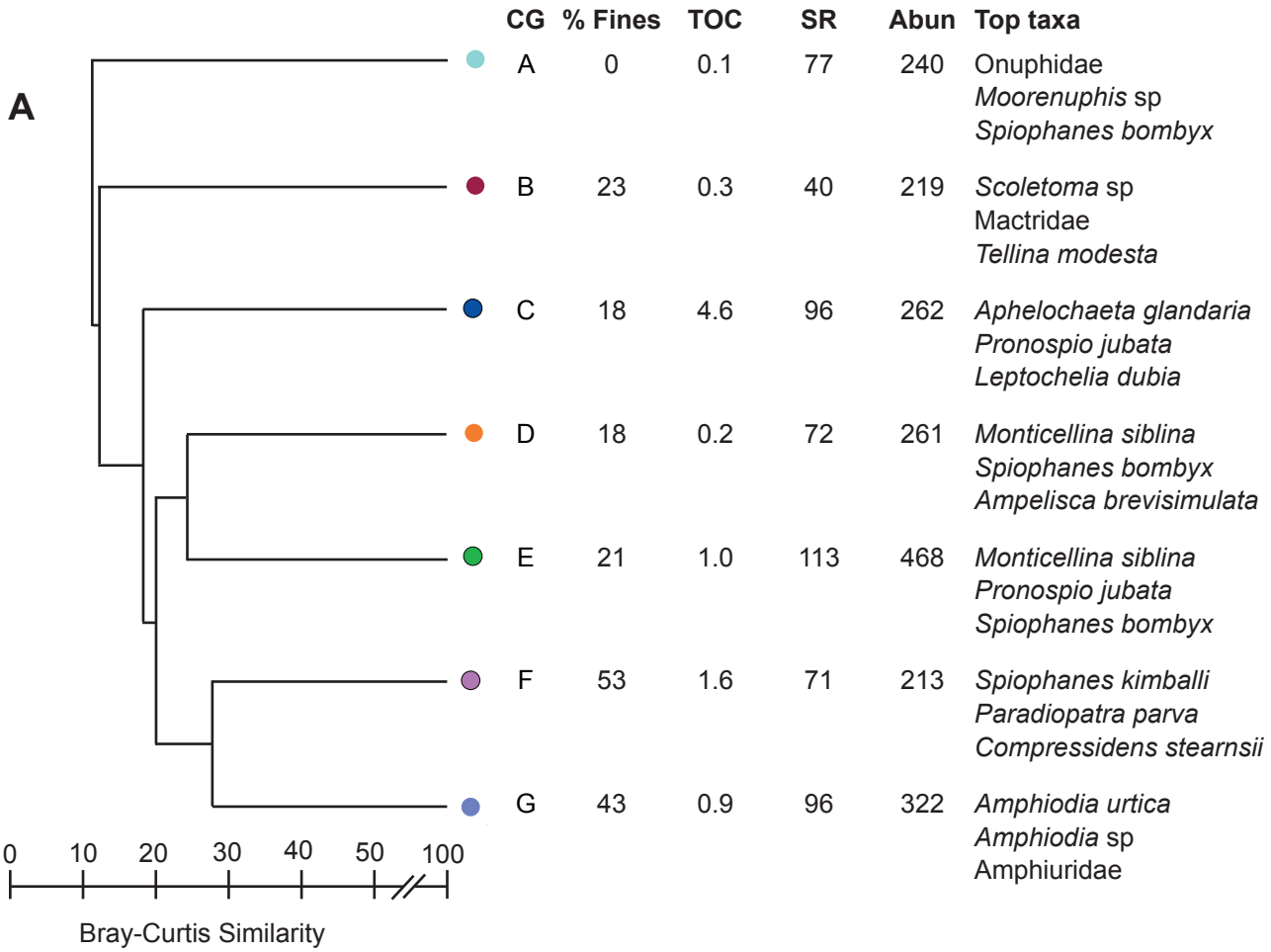

Figure 9.2

(A) Cluster results of the macrofaunal abundance data for the regional benthic stations sampled during July 2006. Data are expressed as mean values per 0.1 m^2 grab over all stations in each group. **(B)** MDS ordination based on square-root transformed macrofaunal abundance data for each station/survey entity. Cluster groups superimposed on station/surveys illustrate a clear distinction between faunal assemblages.

Cluster group C consisted of 2 stations along the Coronado bank (145–157 m). Sediments at this group were relatively coarse and contained pea gravel, rock, and shell hash. These sites averaged 18% fines and had the highest organic load (e.g., TOC = 4.6%). Species richness for this assemblage averaged 95 taxa and abundance averaged 262 individuals per 0.1 m^2. The dominant species included 2 polychaetes, *Aphelochaeta glandaria* and *Prionospio jubata*, as well as the crustacean *Leptochelia dubia*.

Cluster group D consisted of 5 nearshore stations located in the South Bay area that ranged in depth from 16 to 26 m. Sediments at stations within this group averaged 18% fines. Overall, the benthic assemblage at these stations was typical of the shallow water sites in the region (e.g., see Chapter 5). Group D averaged 72 taxa and 261 individuals per 0.1 m^2. The dominant species included the polychaetes *Monticellina siblina* and *Scoletoma* sp, as well as the amphipod *Ampelisca brevisimulata*.

Cluster group E included sites primarily located along the 19 and 28 m depth contours, where sediments contained 23% fine particles. TOC at stations within this group averaged 1.0%. This assemblage averaged the highest species richness (113 taxa) and abundance (468 individuals per 0.1 m^2). Three polychaetes, *Prionospio jubata*, *M. siblina,* and *S. bombyx* were the numerically dominant species in this group.

Cluster group F represented 4 of the 7 outer shelf stations, including 3 of the deepest sites (mean depth=181 m). This group contained 53% fine sediments and averaged the second highest concentration of TOC (1.6%). The number of taxa at group F averaged 71 taxa and 213 individuals per 0.1 m^2. The most abundant species were the polychaetes *Spiophanes kimballi* and *Paradiopatra parva*, and the mollusc *Compressidens stearnsii*.

Cluster group G comprised most of the mid-shelf sites ranging in depth from 52 to 123 m. This cluster group, characterized by mixed sediments averaging 43% fines (range=19–64%), had the second highest average species richness (96), and the second highest values for abundance (322). This assemblage is typical of the ophiuroid dominated community that occurs along the mainland shelf off southern California (City of San Diego 2006). The most abundant species representing this mid-shelf group were the ophiuroid *Amphiodia urtica,* the polychaete *Spiophanes duplex,* and the bivalve *Axinopsida serricata*.

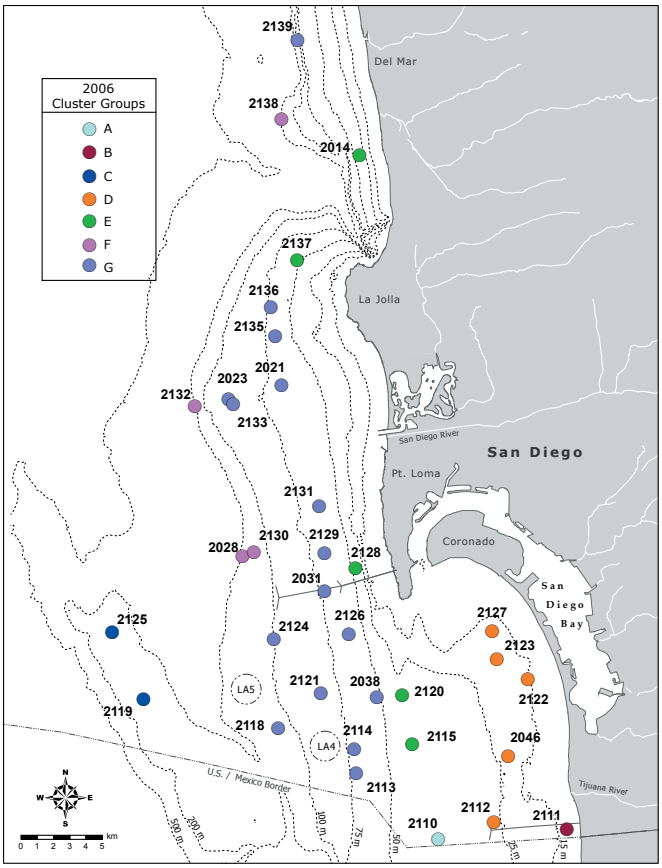

Figure 9.3
Regional benthic stations sampled during July 2006, color-coded to represent affiliation with benthic cluster groups.

SUMMARY AND CONCLUSIONS

The Southern California Bight (SCB) benthos has long been considered a patchy habitat, with the distribution of species and communities varying in space and time. Barnard and Ziesenhenne (1961) described the SCB shelf as consisting of an *Amphiodia* mega-community with other sub-communities representing simple variations

Table 9.3

Summary of the most abundant taxa composing cluster groups A–G from the 2006 regional benthic station survey. Data are expressed as mean abundance per cluster group and represent the 10 most abundant taxa in each group. Values for the 3 most abundant species in each cluster group are bolded. n=number of station/survey entities per cluster group

		Cluster group						
		A	B	C	D	E	F	G
Species/Taxa	Taxa	(n=1)	(n=1)	(n=2)	(n=5)	(n=5)	(n=4)	(n=22)
Ampelisca brachycladus	Crustacea	—	—	—	6.2	—	—	—
Ampelisca brevisimulata	Crustacea	—	—	—	**10.4**	7.0	1.0	2.0
Ampelisca cristata cristata	Crustacea	11.0	—	—	5.0	—	—	0.3
Amphiodia sp	Echinodermata	—	—	1.0	—	1.4	0.3	**19.9**
Amphiodia urtica	Echinodermata	2.0	—	—	—	0.4	0.5	**52.3**
Amphiuridae	Echinodermata	—	1.0	—	0.4	3.2	1.8	**13.4**
Aphelochaeta glandaria	Polychaeta	—	—	**25.5**	0.4	1.6	1.8	0.6
Axinopsida serricata	Mollusca	—	—	—	—	0.6	0.5	11.6
Compressidens stearnsii	Mollusca	—	—	1.5	—	—	**7.0**	0.1
Foxiphalus obtusidens	Crustacea	**15.0**	—	1.0	1.4	8.6	—	0.3
Huxleyia munita	Mollusca	—	—	8.5	—	—	—	—
Leptochelia dubia	Crustacea	6.0	—	**12.0**	1.2	6.8	0.3	5.1
Mactridae	Mollusca	—	**28.0**	—	—	—	—	—
Mediomastus sp	Polychaeta	—	4.0	1.0	8.6	5.8	4.0	2.6
Monticellina siblina	Polychaeta	—	—	7.5	**44.4**	**24.6**	1.5	0.6
Mooreonuphis exigua	Polychaeta	—	—	8.0	—	—	—	—
Mooreonuphis sp	Polychaeta	**19.0**	—	3.0	—	1.8	—	0.3
Nassarius sp	Mollusca	—	19.0	—	0.4	0.2	—	—
Notoproctus pacificus	Polychaeta	—	—	—	—	16.6	—	—
Onuphidae	Polychaeta	**23.0**	2.0	2.0	—	0.2	—	0.1
Onuphis sp A	Polychaeta	—	12.0	—	3.0	3.0	—	0.3
Paradiopatra parva	Polychaeta	—	—	2.0	—	0.2	**14.8**	1.9
Paraprionospio pinnata	Polychaeta	—	1.0	2.0	3.6	4.0	5.8	3.4
Phyllochaetopterus limicolus	Polychaeta	—	—	—	—	—	6.0	0.1
Prionospio jubata	Polychaeta	—	—	**13.0**	0.8	**24.8**	2.8	5.2
Scoletoma sp	Polychaeta	—	**51.0**	—	**10.4**	—	3.0	1.1
Spiophanes bombyx	Polychaeta	**15.0**	1.0	—	2.6	**24.2**	—	0.6
Spiophanes duplex	Polychaeta	—	5.0	0.5	5.6	13.6	2.3	7.8
Spiophanes kimballi	Polychaeta	—	—	0.5	—	—	**34.3**	1.4
Syllis heterochaeta	Polychaeta	—	—	—	0.2	14.6	0.5	0.9
Tellina modesta	Mollusca	—	**21.0**	—	2.6	1.2	—	—

determined by differences in substrate type and microhabitat. Results of the 2006 and previous regional surveys off San Diego generally support this characterization. The 2006 benthic assemblages segregated mostly by habitat characteristics (e.g., depth, sediment grain size, and TOC) and were similar to those sampled in the past.

Almost half of the benthos off San Diego was characterized by an assemblage dominated by the ophiuroid *Amphiodia urtica* (Station group G). *Amphiodia urtica*, a dominant species along the mainland shelf of southern California, averaged 25 animals per 0.1 m^2 (Table 9.2). The co-dominant species within this assemblage included other taxa common to the region such as the polychaete *Spiophanes duplex*.

Nearshore assemblages in the region varied depending upon the sediment type and depth where they were collected, but were generally similar to other shallow, sandy sediment communities in the SCB (see Barnard 1963, Jones 1969, Thompson et al. 1987, 1992, ES Engineering-Science 1988, Mikel et al. 2007). At groups D and E, polychaete species such as *Monticellina siblina* were numerically dominant in mixed, sandy sediments. However, the single site (2110) that constituted group A was characterized by unique, coarse sediments composed of relict red or black sands that are typically associated with distinct benthic assemblages. This assemblage was dominated by the polychaetes *Moorenuphis* sp and *Spiophanes bombyx*, and the crustacean *Foxiphalus obtusidens*, the latter species being rare at most other assemblages. Another shallow water assemblage, group B, occurred at a depth of 12 m, and contained taxa associated with shallow habitats exposed to water motion like Mactrid bivalves, the polychaete *Chone* sp SD1, and the gastropod *Nassarius* sp.

The deepest sites (group F, >180 m) had the highest percentage of fine particles and second highest TOC concentrations. These sites had a relatively lower species richness and abundance and were dominated by polychaetes, including *Spiophanes kimballi, Paradiopatra parva*, and *Paraprionospio pinnata*.

Figure 9.4
MDS ordination of regional benthic stations sampled in July 2006. Cluster groups A–G are superimposed on stations. Percentage of fine particles in the sediments, station depth, and total organic carbon (TOC) are further superimposed as circles that vary in size according to the magnitude of each value. Plots indicate associations of macrobenthic assemblages with habitats that differ in sediment grain size and depth. Stress=0.14.

The results of the 2006 regional survey off San Diego indicated that benthic assemblages in the vicinity of the Point Loma Ocean Outfall, the South Bay Ocean Outfall, and the dredge spoils disposal sites have maintained a benthic community structure consistent with regional assemblages sampled in the past (e.g., City of San Diego 2005, 2006) and the SCB as a whole (e.g., Mikel et al. 2007). While assemblages varied based on depth, sediment composition, and TOC concentrations, no patterns of disturbance relative to point sources were evident. Abundances of soft-bottom invertebrates exhibit substantial spatial and temporal variability that may mask the effects of natural or anthropogenic disturbances (Morrisey et al. 1992a, 1992b, Otway 1995). However, region-wide surveys are valuable tools that provide context for localized monitoring and help to establish the baseline conditions necessary to identify any natural or anthropogenic disturbances.

There were no substantial changes in community parameters between the 1996 random and 2006 surveys. Over the 10 year period, changes in taxonomic resolution created some disparity in nomenclature among select species. For example, certain species complexes (e.g., *Americhelidium*, *Chaetozone*) have been further resolved into individual species. These types of changes can account for some of the differences in species richness and the associated diversity indexes. However, the similarities between macrofaunal community parameters from 1996 and 2006 suggest that benthic assemblages have not changed substantially in recent years.

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